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MARINE FOULING AND BORING ORGANISMS IN THE TONGUE OF THE OCEAN, BAHAMAS - EXPOSURE II.

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ABSTRACT

A 111-day marine fouling and corrosion experiment was performed in the Tongue of the Ocean during the period 5 April to 25 July 1962, the second in a series to determine the effects of the deep sea environment on various materials.

Marine fouling organisms were found attached to a mooring line in the TOTO in moderate to severe amounts in the upper 100 meters, slight to moderate from 100 to 300 meters, and slight thereafter to about 1,600 meters. No attachment was noted between 900 and 1,200 meters or below 1,600 meters. Test boards exposed directly on the bottom contained the boring mollusc Xylophaga sp. Corrosive processes were pronounced at depth. The experimental program is being expanded and continued.

ACKNOWLEDGMENTS

Taxonomic confirmations by the U. S. National Museum and the William F. Clapp Laboratory are gratefully acknowledged.

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MARINE FOULING AND BORING ORGANISMS IN THE TONGUE OF THE OCEAN, BAHAMAS - EXPOSURE II

INTRODUCTION

A cooperative program of deep sea test panel exposures is being conducted in the Tongue of the Ocean (TOTO) by the U. S. Naval Oceanographic Office (NAVOCEANO), the Naval Research Laboratory (NRL), and the U. S. Naval Underwater Ordnance Station (NUOS) in support of BUSHIPS projects.

These investigations are being performed to compare and assess the corrosive behavior of important metal alloys and to acquire fundamental information regarding marine growth (rates and amounts of accumulation as well as seasons of maximum and minimum attachment) in a deep sea environment.

This is a report of the marine growth at 3 exposure sites during the period 5 April to 25 July 1962, and is the second in a series of exposures to be performed in the TOTO.

BACKGROUND

Biological Fouling is the term commonly employed to denote the harmful results of marine growth on man-made submerged structures. Fitzgerald and others (1947) determined that the effect of marine growth on the acoustic efficiency of sonar equipment is extremely serious, resulting in an average attenuation of about 3 db per inch of fouling thickness. It has also been determined that marine growth will interrupt

the streamlines of acoustic devices and increase the noise and resistance to water movement.

Marine growth may have a destructive effect on protective coatings intended to reduce corrosion, and serious pitting occurs in areas of localized breaks in the coating. Some fouling organisms increase the corrosion of unprotected metal by the creation of oxygen concentration cells at the point of adhesion, thereby accelerating the metallic breakdown by galvanic mechanisms. It is also felt that metabolic products of fouling, particularly the production of acid conditions and hydrogen sulfide by dying members of the community, create conditions favorable for corrosion.

Marine borers cause considerable damage to submerged installations. The molluscan borer Teredo is most destructive and will attack wood, asphalt, bakelite, neoprene, manila, sisal, and various plastics (NAVDOCKS, 1951). Species of Xylophaga have been recorded repeatedly in submarine cables, where they penetrated such materials as gutta-percha, hemp, and jute. The crustacean borer Limnoria is nearly always found in wood but will also bore into submarine cables (Calman, 1936). Although fouling growth accumulates to some degree on all exposed materials, individual genera demostrate noteworthy rejection of or preference for materials having various surface textures, colors, compositions, etc. Effort was made in these tests to provide a favorable habitat for attachment and growth.

LOCATIONS

Deep Site - The NRL deep-moored array was anchored in approximately 1,737 meters of water at 24°54'N 77°49.5'W (Fig 1 and 2) about 3 miles off northeastern Andros Island in the Bahamas.

The environment is tropical oceanic, currents are weak and generally wind influenced in the upper layers (Magnitzky and French, 1960), the bottom consists of a dominantly silt-size calcareous ooze (Busby, 1962), the transparency is extremely high with penetrations of incident light as deep as 150 meters (Univ. of Miami, 1958), and relatively stable water occurs below the mixed layer (NAVOCEANO, 1962). Representative temperature and salinity profiles are shown in Figure 3.

Shallow Sites - The NAVOCEANO shallow-water companion exposure sites were established at pierside locations at Fresh Creek, Andros Island and Clifton Point, New Providence Island (Fig 1) in an attempt to determine distribution patterns and relative accumulation of marine growth in the TOTO.

METHODS AND MATERIALS

The deep-moored and companion pierside studies were designed for 3-month uninterrupted exposures, subject to ship scheduling delays.

The NRL deep-moored array consisted essentially of a length of 5/8 inch polypropylene line suspended beneath a marker buoy and held in place by 300 pounds of chain and a navy anchor. Steel panels, some cathodically protected, were exposed in aluminum racks at 14, 1,722, and 1,737 meters below the surface for corrosion rate comparisons. In addition, various metal and nonmetal panels were exposed at the deep

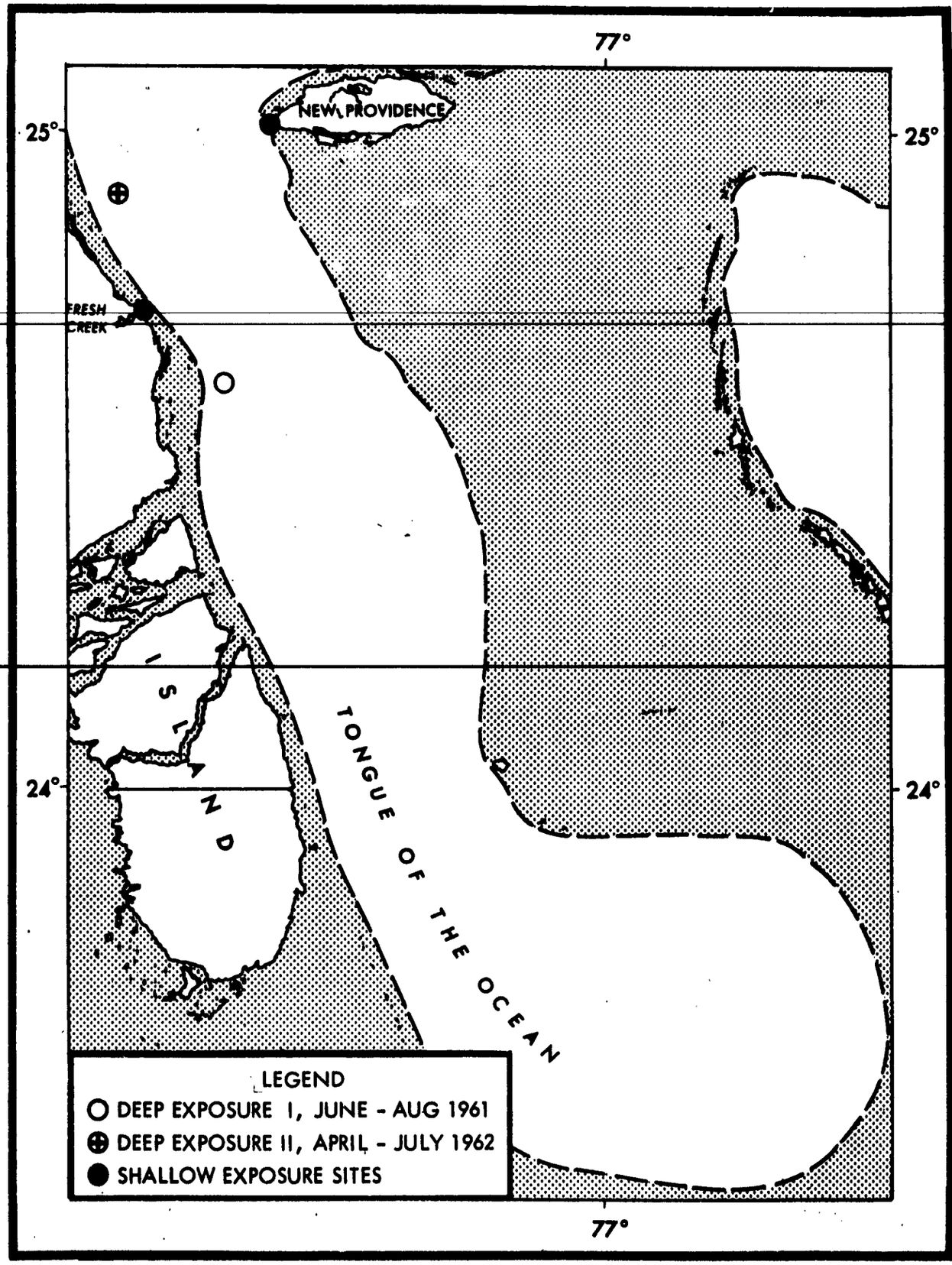

FIGURE 1 TEST SITE LOCATIONS

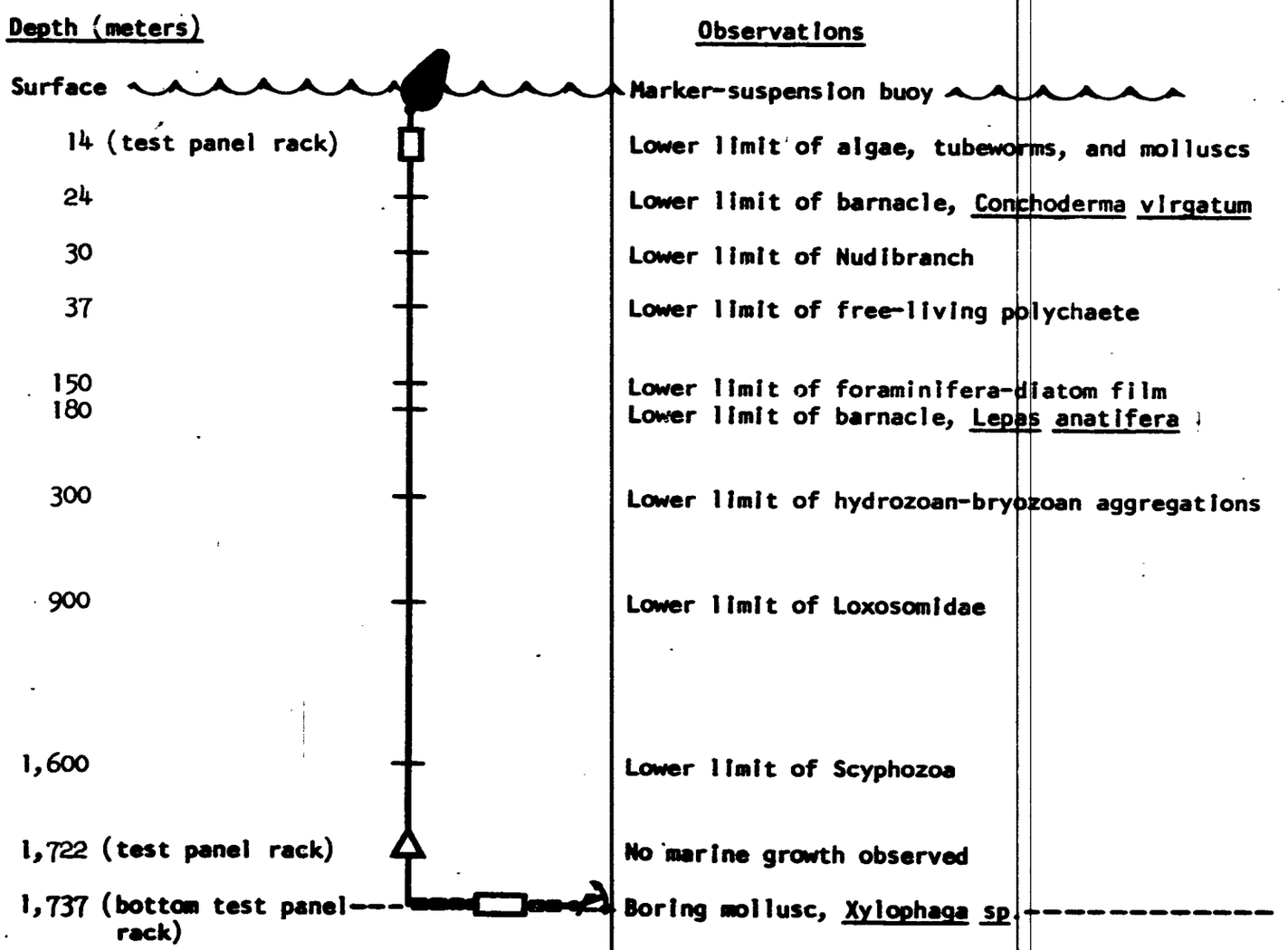

FIGURE 2 SKETCH OF THE NRL DEEP-MOORED TEST PANEL ARRAY

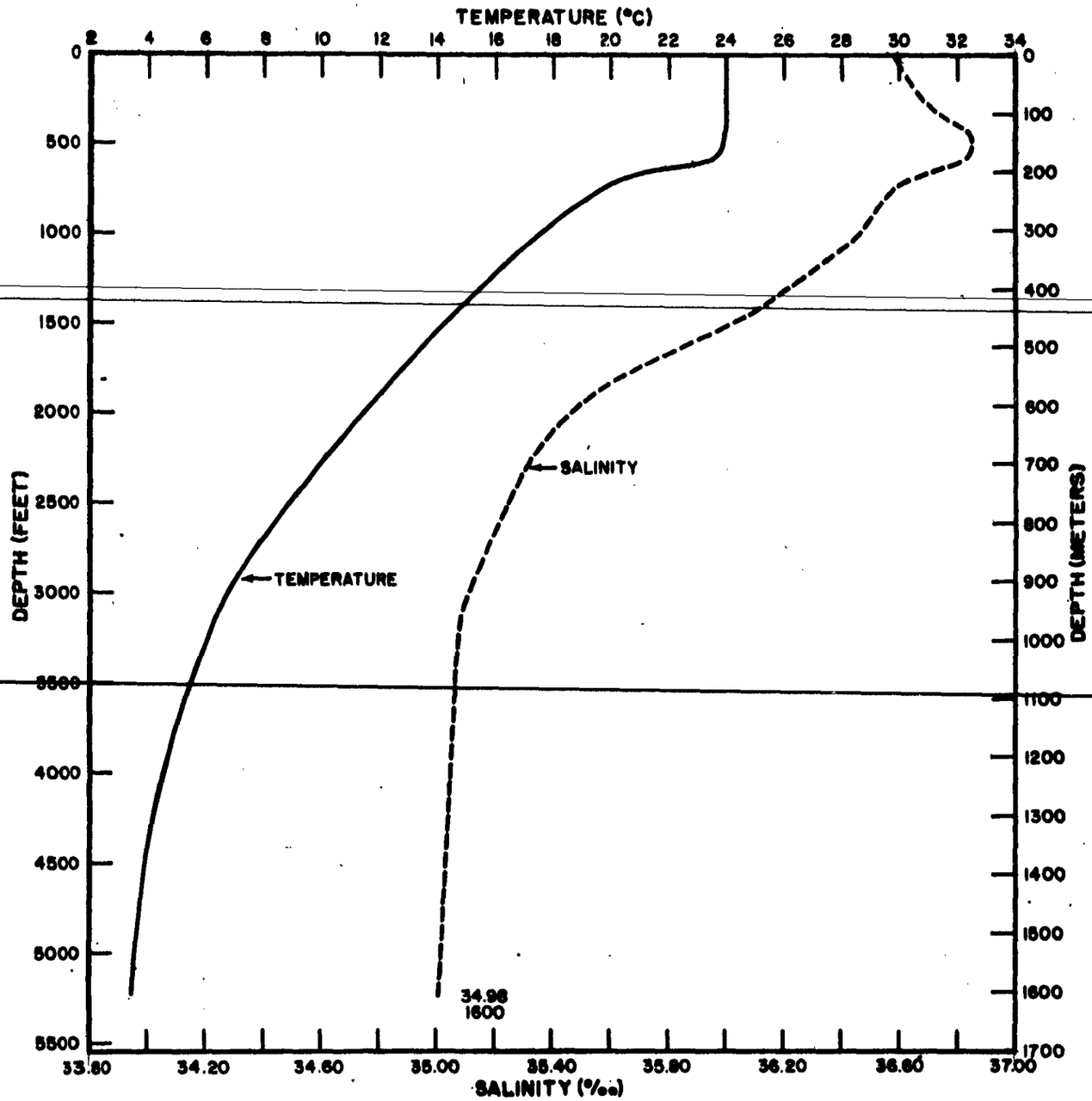

FIGURE 3 TYPICAL TEMPERATURE AND SALINITY PROFILES, UPPER TOTO

racks for other agencies (BUSHIPS, NUOS, and NAVOCEANO).

At Fresh Creek and Clifton Point test panels were exposed near the bottom at 5 meters and 6 meters, respectively, using panel holders suspended beneath piers. These sites are the first in a series to be established to determine distribution patterns of the important organisms in the TOTO.

The NAVOCEANO test panels were constructed of 1/4 inch asbestos board and 3/4 inch white pine, cut into convenient 6 x 12 inch sections and attached back to back. These materials provide a dark, roughened surface for the attachment of fouling forms and an untreated wooden surface for borers. These test panels are considered to be ideal collectors for studies of marine growth.

The test panels were photographed and analysed grossly in the field, then preserved in alcohol and shipped to NAVOCEANO for more detailed study. Analysis consisted of identification of the various forms and determination of numbers, sizes, and/or percentage of test panel coverage.

OBSERVATIONS - DEEP SITE

Marine Growth on the Mooring Warp - Fouling organisms were found attached to the polypropylene line in moderate to severe amounts in the upper 100 meters, becoming slight to moderate to a depth of about 300 meters, and slight thereafter to about 1,600 meters. There was no attachment between 900 and 1,200 meters or below 1,600 meters.

Stalked barnacles, bryozoa, and hydroid coelenterates dominated the upper 100 meters. Barnacles attained a maximum shell length of 2.0 cm in the first 20 meters below the surface, became progressively smaller to a

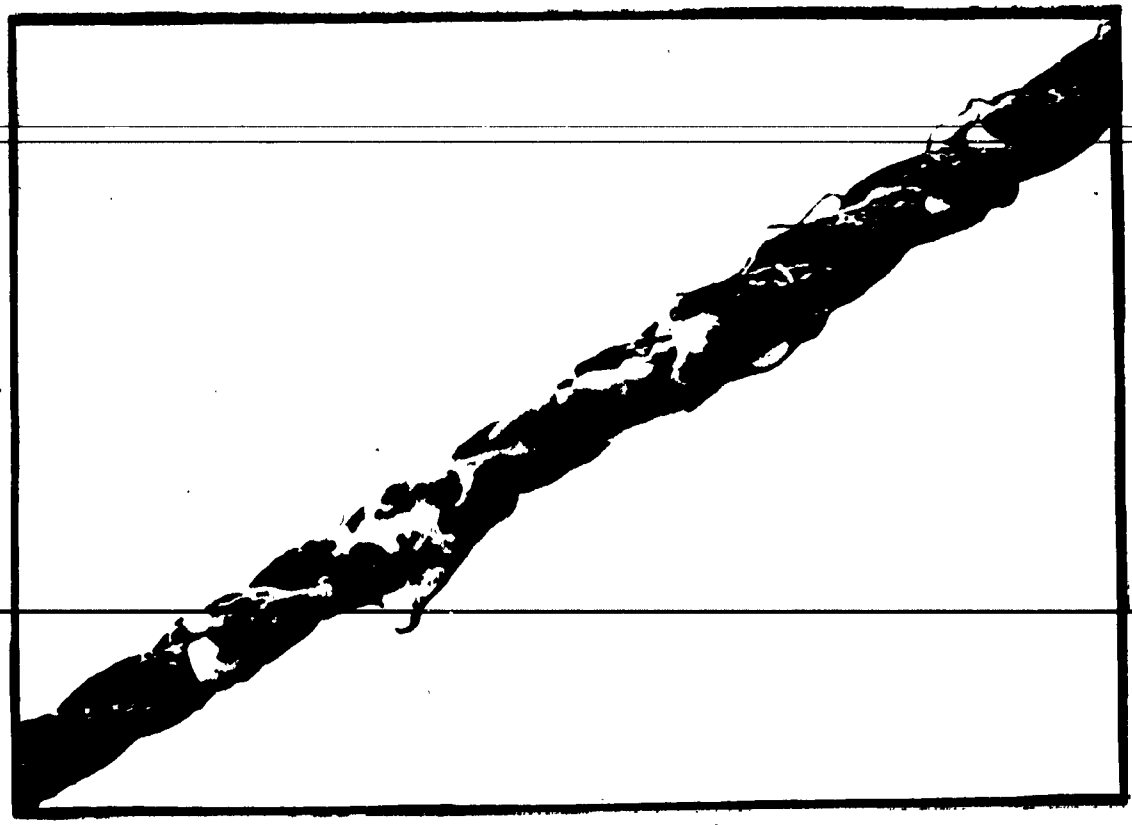

PLATE I PHOTOGRAPH OF SCYPHOZOA ATTACHED TO THE LINE EXPOSED AT APPROXIMATELY 1,600 METERS

minimum length of 0.5 cm at about 90 meters, and then increased to a length of 1.2 cm at about 180 meters (their deepest occurrence). A hydroid-bryozoan mat attached to the line, often in aggregations reaching a thickness of 2.0 cm and covering 2 to 3 feet of the line. Intervals between aggregations increased from about 10 feet near the surface to about 50 feet near 300 meters.

A species of Loxosomidae occurred in the middle depths (300 to 900 meters) in light amounts and showed no apparent layering. A Scyphozoan coelenterate (amorphous when observed, possibly Stauromedusan) occurred between 1,200 and 1,600 meters. It has not yet been definitely determined whether this organism was attached to or merely collected by the line. Lepas barnacles attached to the copper-base antifouling paint surface of the marker buoy in moderate amounts.

Marine Growth on Test Panels - A moderate to severe growth of algae, hydroids, and erect bryozoans was observed on all panels in the 14-meter test rack. A few individual molluscs and barnacles were also attached, mostly in concavities of the rack itself.

No fouling organisms were observed on any of the materials exposed at the 1,722- or 1,737-meter levels; however, a moderate attack of the boring mollusc Xylophaga sp. was evident on wooden panels exposed directly on the bottom. A complete tabulation of the fouling complex on the NRL array is given in Table 1.

Corrosion - Preliminary qualitative evaluation of the steel panels by NRL indicates that the corrosion rate near the bottom was intense, and, generally speaking, the current output required of the galvanic anodes

Organism	Test Materials	Depth (meters)	Relative Occurrence and/or Number	Size and/or Percent Coverage
Diatom-foraminifera slime film	steel panels, aluminum frame, and plastic line	0-150	moderate	100% coverage
Red and green algae	steel panels, aluminum frame, and plastic line	0-14	slight	5% coverage
Hydrozoa-bryozoa	steel panels, aluminum frame, and plastic line	0-300	moderate to severe	2 cm in height, 20-80% coverage
Scyphozoa	plastic line	1,200-1,600	slight, 1 per 30 ft	0.5-3.0 cm in length
Anthozoa-madreporaria	aluminum frame and plastic line	0-14	rare, 4 only	0.5 cm in height
Bryozoa-Lcxosomidae	plastic line	300-900	slight, 1 per 15 ft	1.0 cm in height
Polychaete-free living	plastic line	37	rare, 1 only	7.0 cm in length
Polychaete-calcareous tube	steel panels and aluminum frame	0-14	slight, 0.5 per ft^2	1.5 cm in length
Cirripedia-Lepas anatifera	aluminum frame, plastic line, and antifouling paint on buoy	0-180	moderate, 1 per ft^2	0.5-2.0 cm in length
Cirripedia-Conchoderma virgatum	steel panels, aluminum frame, and plastic line	0-24	slight, 0.2 per ft^2	0.5 cm in length
Mollusc-Pinna carnea	aluminum frame and plastic line	0-14	rare, 3 only	1.0 cm in length
Mollusc-Pinctada radiata	aluminum frame and plastic line	0-14	rare, 3 only	1.5 cm in length
Mollusc-Anomia simplex	aluminum frame	14	rare, 2 only	0.7 cm in length
Boring mollusc-Xylophaga sp.	wood panel	1,737	moderate, 10-12 per in^2	immature, 50% coverage
Nudibranch-Scyllaea pelagica	aluminum frame and plastic line	0-30	slight, 1 per 15 ft	0.2-0.9 cm in length

TABLE 1 MARINE GROWTH, NRL DEEP-MOORED TEST PANEL ARRAY

increased with depth. A complete report of the corrosion analysis is being prepared by the NRL Marine Corrosion Section.

OBSERVATIONS - SHALLOW SITES

Marine fouling was moderate to severe at both Fresh Creek and Clifton Point and similar in gross appearance to the test at 14-meters at the deep site. The dominant forms were hydrozoans and algae, which accumulated to a thickness of 2.0 cm. Hard-shelled forms (barnacles, molluscs, and tubeworms) were minor foulers at both shallow locations, and none attained significant size during the 111-day period of exposure.

The crustacean borer Limnoria lignorum infested the wooden panels in moderate amounts at Clifton Point and slight amounts at Fresh Creek. Infestations of the boring mollusc Teredo sp. occurred in slight amounts at Clifton Point.

A complete comparison of the relative occurrence of marine growth at both the shallow sites and near-surface deep sites is presented in Table 2.

SUMMARY

Marine fouling at 3 test sites in the TOTO was moderate to severe and occurred in significant amounts to 1,600 meters. This is deeper by about 1,200 meters than was noted during the June to August 1961 exposure at a deep-moored site off High Cay (DePalma, 1962).

No hard-shelled forms were collected below the upper or mixed layer. However, no panels were hung between 14 and 1,722 meters below the surface on the NRL deep-moored array.

Organism	Coverage in Deep Exposure I (13 meters)	Coverage in Deep Exposure II (14 meters)	Fresh Creek (bottom test - 5 meters)	Clifton Point (bottom test - 6 meters)
Diatom slime film	100%	100%	100%	100%
Hydroid-bryozoan mat	90%	85%	100%	100%
Red and green algae	40%	30%	40%	40%
Encrusting bryozoan	0	0	0	5%
Anthozoa	0	trace	0	0
Free living polychaete	0	trace	1%	trace
Serpulid polychaete	0	trace	1%	trace
Balanus sp.	1%	0	0	1%
Lepas anatifera	2%	2%	0	1%
Conchoderma virgatum	1%	1%	0	0
Pinna carnea	0	trace	0	0
Pinctada radiata	0	trace	0	trace
Anomia simplex	0	trace	0	0
Teredo sp.	trace	0	0	trace
Scyllaea pelagica	0	trace	0	0
Limnoria Lignorum	0	0	slight	moderate
Colonial ascidian (*Botryllus sp.*)	0	0	trace	10%

Note: Trace indicates less than 1% coverage.

TABLE 2 SUMMARY OF MARINE GROWTH IN TEST EXPOSURES

Two species of marine borers occurred in slight to moderate amounts in shallow water and a third occurred in moderate amounts in wooden panels exposed directly on the bottom at 1,737 meters.

FUTURE PLANS

Test panel exposures will be continued at the present sites and will also be established at 15 new locations to determine areal and seasonal distribution of marine growth in the TOTO. At the deep-moored sites, attempts will be made to pinpoint seasonal lower limits of fouling occurrence. Longer periods of exposure and new sites are contemplated.

While the present mooring design seems practical and remains basically unchanged (taut-line moor using synthetic warp and a surface buoy), each new experimental exposure incorporates refined equipment and reflects improved techniques.

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